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THE HOMES OF BLINDFISHES

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Dean of the Graduate School, Indiana University

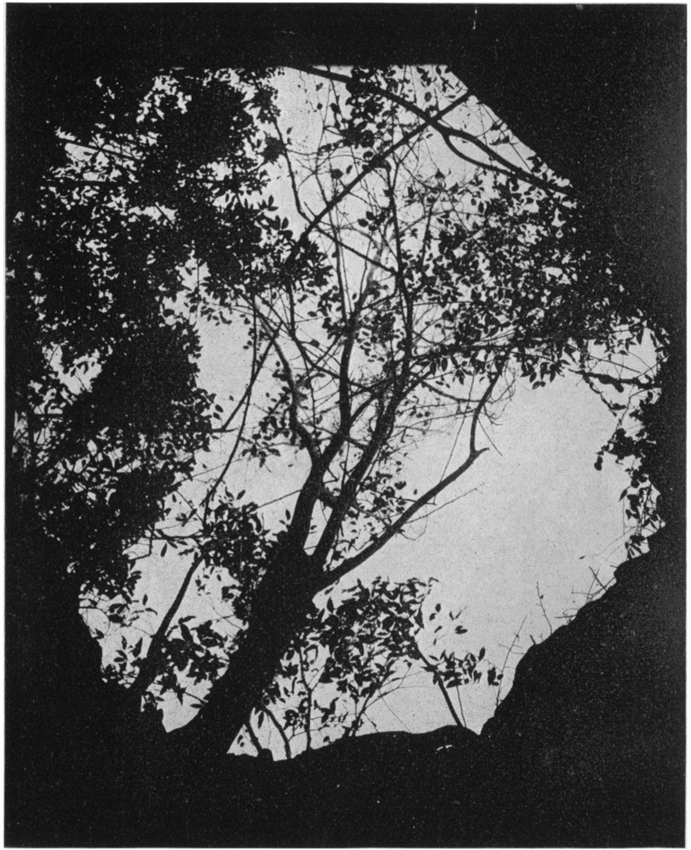
Blindfishes are found wherever darkness or semi-darkness and isolation, conditions suitable for their existence, have prevailed for a sufficient length of time. They are found in the depths of the ocean, in limestone caverns, and in cracks and burrows of various sorts. Their distribution and characteristics form one of the highly interesting chapters of the science of zoögeography.

Blindfishes' eyes are in various stages of degeneration. In some blindfishes the eye begins to develop in the normal way, but sooner or later it lags behind the other structures in rate of growth and differentiation, and then it stops growing altogether. Some parts of the eyes stop growing sooner than others. Soon after the development of the eye has ceased, it begins to degenerate. The lens stops growing first and is the first part of the eye to begin to degenerate. The example of the lens is followed sooner or later by other portions of the eye, so that in old age there is frequently nothing left in the remotest way resembling an eye.

Most of the localities where blindfishes are found are monotonous in the extreme. The depths of the ocean know no changes from day to night, from season to season, from year to year. Such trifling changes as there are probably are not perceptible during the lifetime of any individual. Even in limestone caverns in the temperate zone, the diurnal changes are practically nil and the seasonal temperature changes are but slight. But there is much difference from place to place in the clarity of the water, the amount of water, and the rate of the current. The fluctuation in the height of the River Styx in Mammoth Cave, Kentucky, is said to amount to sixty feet. The river in Shawnee Cave, Indiana, sometimes fills the cave to the top, and in temperature it ranges from about 45° to 63° F.

Not all fishes living in dark places are blind or have defective eyes. It is safe to say that no fishes that depended on their eyes to secure food, to avoid being food, or to find mates have in the past either colonized caves or gone blind; and it is equally safe to predict that the descendants of the fishes now depending on their eyes will never become blind. The various blindfishes have all been derived from ancestors that could, and probably did, dispense with the use of eyes long before they came to live permanently in dark places.

Knowing the above facts, it is a comparatively simple matter to enumerate the families of fishes in which blind members may have developed or that may in the future give rise to blind members. The existing blindfishes



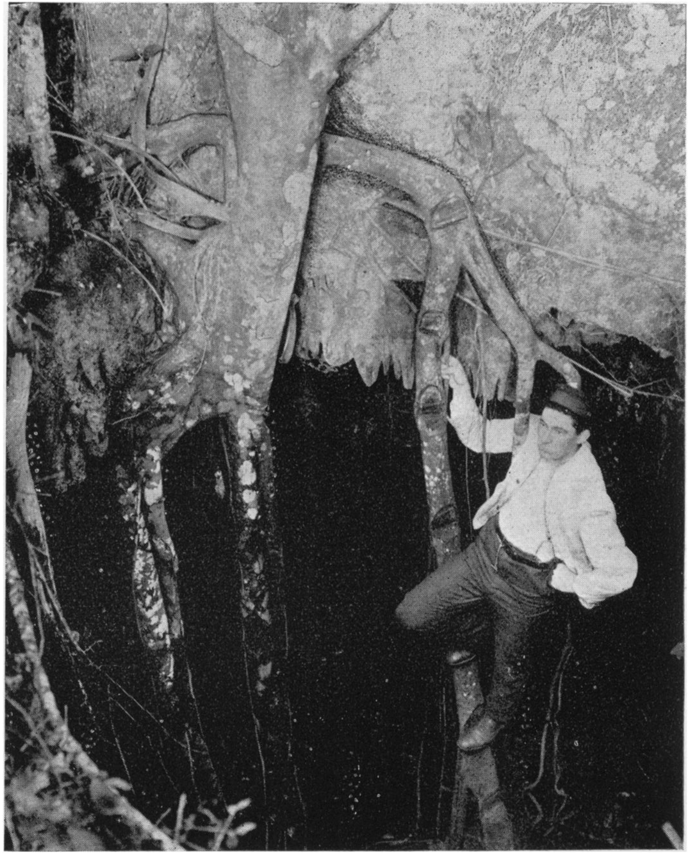
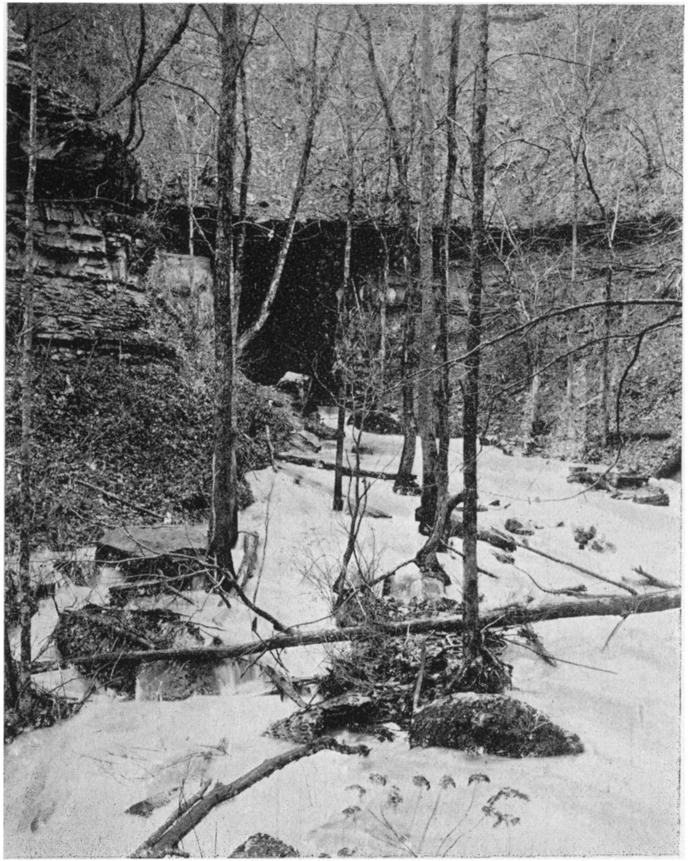


Fig. 1—Looking straight up from the bottom of one of the cistern-like caves near Cañas, Cuba, to the near-circular entrance of the cave. The tree, *Ficus*, sends several roots to the water in the cave.

Fig. 2—Looking obliquely down into the cave of Fig. 1. Notches have been cut in some of the roots, by which one descends to the bottom. Blindfishes can always be found in this cave.



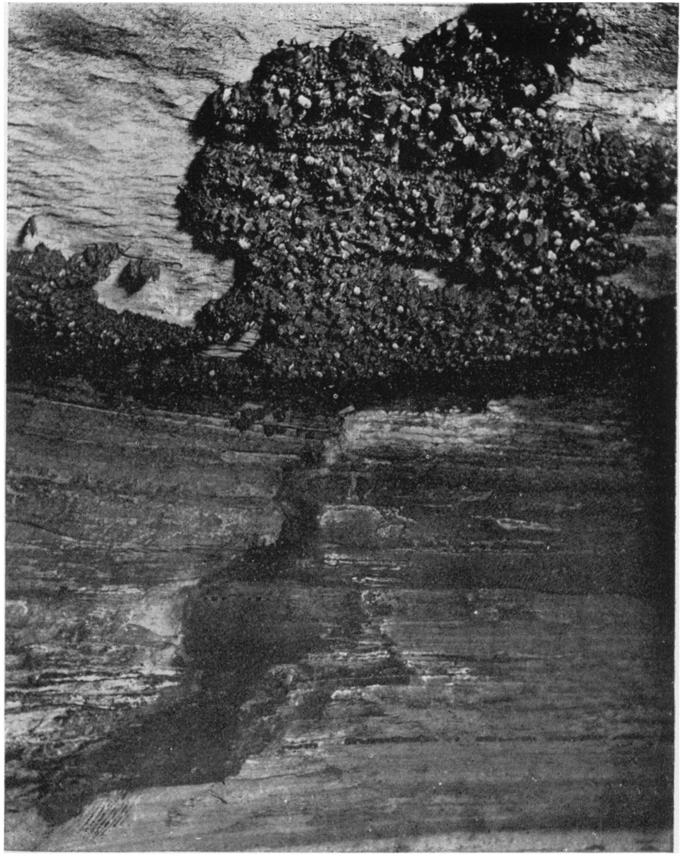


Fig. 3—Blindfish River, Indiana, in flood. At such times it is not possible to enter the cave.

Fig. 4—Bats on the roof of Marble Cave, Missouri. Bats winter in many of the blindfish caves. The bats enter the cave in late summer and fall—apparently as soon as they are fat enough. They at first congregate in the deeper recesses of the cave. Towards spring, as the accumulated fat disappears, they move toward the entrance of the cave and make frequent trials of the out-of-doors. If conditions are unfavorable, they go but a few yards before they return to the cave. If they are favorable they remain outside. (Photo by C. H. Spurgeon.)

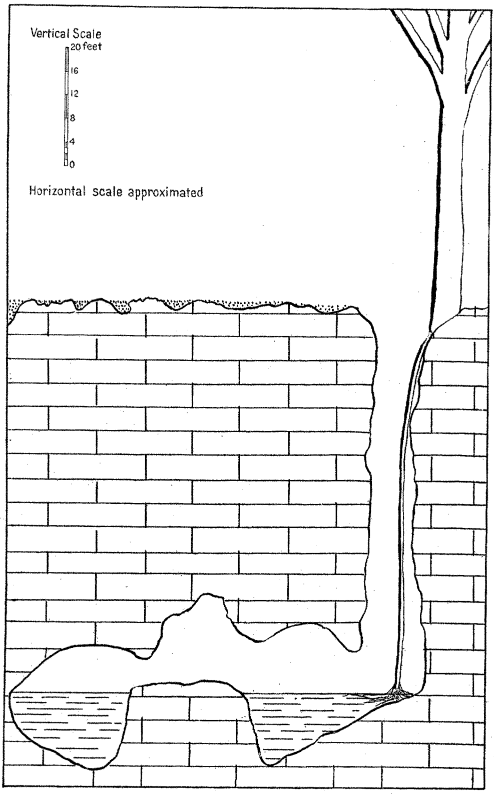


FIG. 5—Explanation on the right.

belong to nocturnal, as distinguished from twilight fishes, and to groups that detect their food and their mates by taste and touch or that live under rocks and in burrows of one sort or another.

I have had experience in catching blindfishes in California, Cuba, and the Mississippi Valley (in Indiana, Kentucky, and Missouri), and I have directed their capture in South America. The blindfishes in these different regions are not related to one another. They are related to epigean, eyed fishes living in the same neighborhood.

FIG. 5—Cave Tranquilidad, southwest of Cañas, Cuba. Figs. 5 and 6 represent various types of Cuban caves. The masonry effect represents the native rock out of which the caves have been dissolved. The water in these caves is so charged with lime and manganese that a crust of these minerals is formed on the unruffled surface of the water as it evaporates.

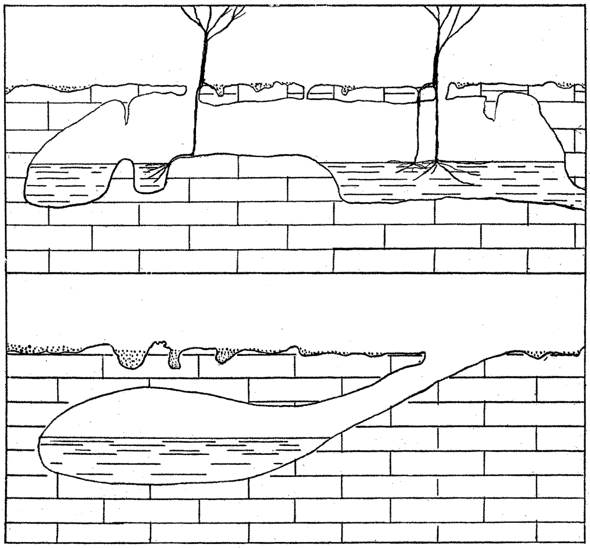
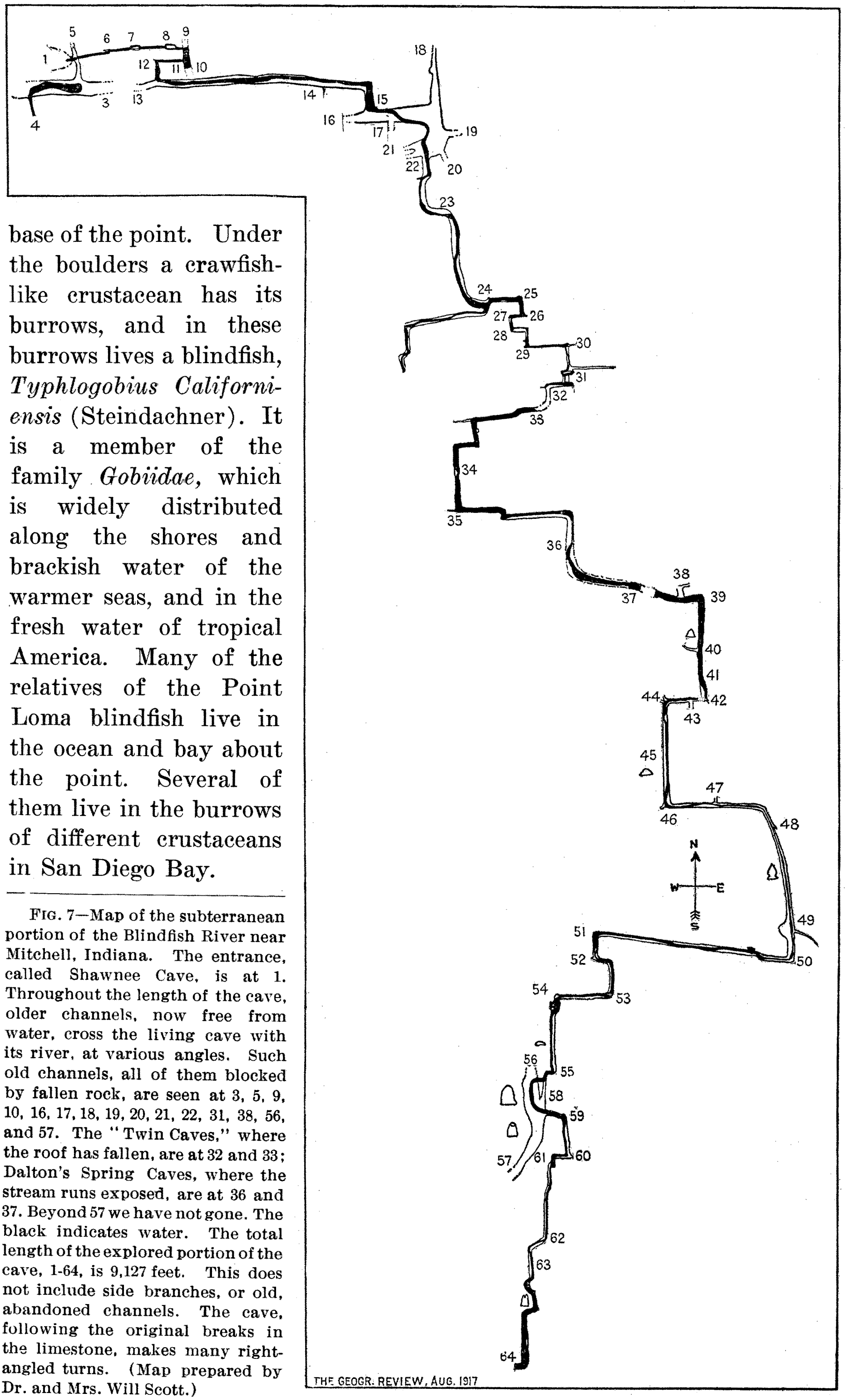


FIG. 6—Explanation on the right.

At San Diego, California, Point Loma sticks its nose into the Pacific. It is composed, among other things, of sandstone, gravel, and water-worn boulders. The waves of the ocean have gnawed off the margin of the point and crumbled up the material at its base. Many of the boulders washed down are half buried in the sand at the

FIG. 6—(Upper) Diagram of a cave near Cañas, Cuba. (Lower) Cave on the Finca San Isidro. For general explanation see Fig. 5.

base of the point. Under the boulders a crawfish-like crustacean has its burrows, and in these burrows lives a blindfish, *Typhlogobius Californiensis* (Steindachner). It is a member of the family *Gobiidae,* which is widely distributed along the shores and brackish water of the warmer seas, and in the fresh water of tropical America. Many of the relatives of the Point Loma blindfish live in the ocean and bay about the point. Several of them live in the burrows of different crustaceans in San Diego Bay.



THE GEOGR. REVIEW, AUG. 1917

FIG. 7—Map of the subterranean portion of the Blindfish River near Mitchell, Indiana. The entrance, called Shawnee Cave, is at 1. Throughout the length of the cave, older channels, now free from water, cross the living cave with its river, at various angles. Such old channels, all of them blocked by fallen rock, are seen at 3, 5, 9, 10, 16, 17, 18, 19, 20, 21, 22, 31, 38, 56, and 57. The "Twin Caves," where the roof has fallen, are at 32 and 33; Dalton's Spring Caves, where the stream runs exposed, are at 36 and 37. Beyond 57 we have not gone. The black indicates water. The total length of the explored portion of the cave, 1-64, is 9,127 feet. This does not include side branches, or old, abandoned channels. The cave, following the original breaks in the limestone, makes many right-angled turns. (Map prepared by Dr. and Mrs. Will Scott.)

FIG. 7—Explanation on the left.

In various places in the Mississippi Valley there are more or less extensive limestone caverns. They are abundant in Missouri, where streams of larger or smaller dimensions course through them, to emerge again beyond. Such caves exist at Sarcoxie, Roaring River, Springfield, and other places. The caves about Sarcoxie harbor a small blindfish in which the eyes have all but vanished. The caves of Kentucky have long been known to harbor two or three different blindfishes, as well as a close relative not actually blind. In Indiana blindfishes have been found from Wyandotte Cave near the Ohio River to Mitchell. The caves in which blindfishes are found more abundantly than elsewhere in America are east of Mitchell, Indiana. Here large areas are covered with sink holes that drain into underground streams which find their exit in the escarpment along White River, sometimes in gorges and caverns of rare beauty. The largest of the underground streams, which leaves its tube by Shawnee Cave, and which can be reached at four other places where the roof has fallen, runs under a tract of land containing 182 acres. This land escheated to the common-school fund of Indiana. The legislature authorized the trustees of Indiana University to buy the land. It is now under the management of Indiana University and will be preserved as a natural monument for future generations.

All of the blindfishes of the Mississippi Valley belong to one family. There are but seven species of this family known to naturalists, and most of them are found in caves. They are the blindfishes *par excellence.*

One, *Troglichthys rosae,* is confined to the caves of southwestern Missouri; *Amblyopsis spelaeus* is found in Indiana and Kentucky. *Typhlichthys* is also found in Indiana and Kentucky, but the species of Indiana is different from those south of the Ohio. There are apparently two species in Kentucky. All externally visible, ornamental differences, such as distinguish different related epigean species, are absent in the blind cave fishes. They are all pink. The eyed relatives of the blindfishes are *Chologaster papilliferus,* living in a cave spring in southern Illinois; *Chologaster agassizii,* found in the caves and springs of Tennessee and Kentucky; and *Chologaster cornutus,* which lives in the swamps of Georgia, South Carolina, and Virginia. The places in which the different species of these fishes live are, for the most part, separated from each other by effective barriers. The Ohio and Mississippi Rivers are probably as effective barriers to the blindfishes as now developed as so much sand would be.

In Conestoga Creek, a tributary of the Susquehanna in Lancaster County, Pennsylvania, Cope secured some blind catfishes with eyes in a variable transition stage. They are simply a blind representative of the ordinary type of Silurids characteristic of North America.

Much of western Cuba is drained by underground streams. From one of them Havana is supplied with water. The streams sometimes run above ground for a distance, then run below ground and reappear again near the coast or even under the surface of the ocean. In many places both east and

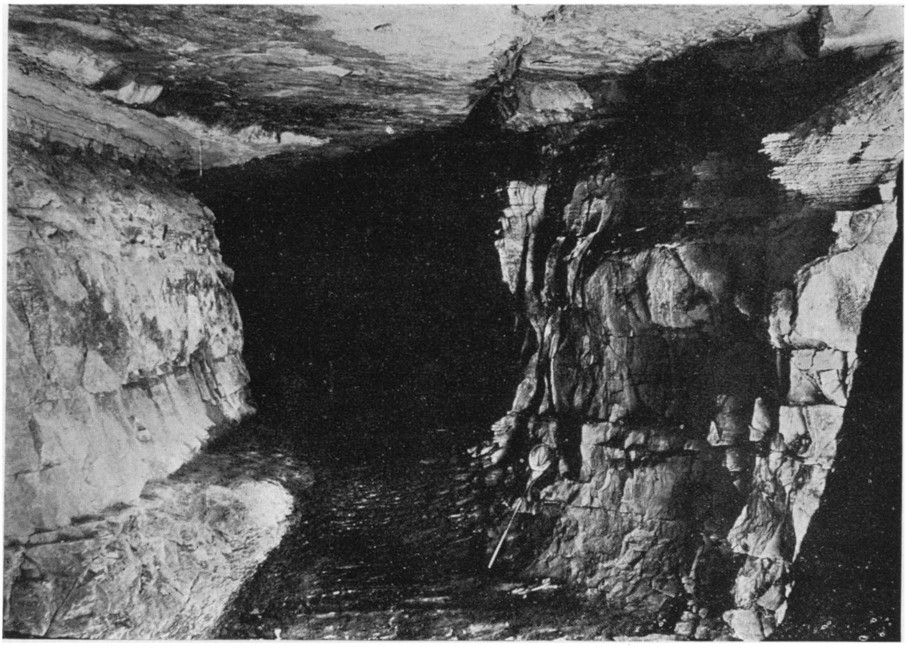


FIG. 8.

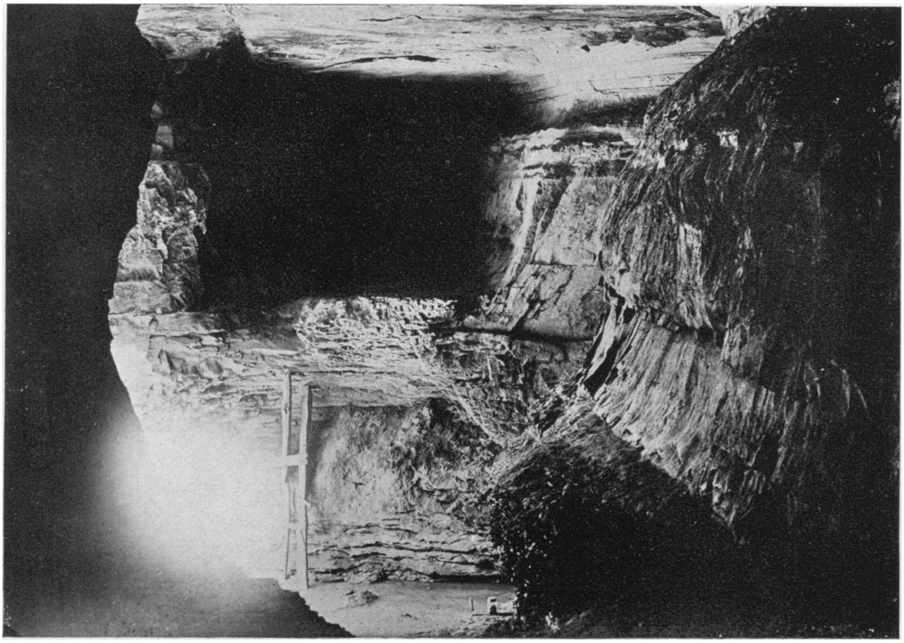


FIG. 9.

FIG. 8—Looking into the south portion of the abandoned dry cave just within the entrance to Shawnee Cave. The abandoned channel has been cut in two by the living cave. During very wet weather a little water still flows out of this channel. For indication of size, note the collecting net on the right wall. (Photo by Drs. F. Payne and N. Miller.)

FIG. 9—Looking north into the continuation of the dry cave, opposite the one shown above. This portion is permanently dry. A few tools once used by Indians were found in this part of the cave. Light entering the cave and reflected from the wall has fogged the spot in the lower left corner. For indication of size, note the collecting bottle on the ground. (Photo by Drs. F. Payne and N. Miller.)

west of Havana there are *cenotes,* or natural wells or caves. The ground may be quite level, when one comes suddenly on a circular opening of greater or less extent. This usually leads into a conical, sometimes irregular cave containing water in which blindfishes are found. Sometimes half of the roof of the cavern has fallen so that one can walk down to the water, but usually one has to climb down. This is often made easy by a tree, *Ficus,* which is found at the mouth of the cave and sends aërial roots through the cave to the water.

In many of the caves of Cuba stalagmites rise from some distance below the water, showing that the water in these caves has risen in recent years, that is, this portion of the island has been lowered. The water is surcharged with lime and magnesium, and, as its surface is not disturbed, a crust of these minerals forms over the water with evaporation.

The blindfishes of Cuba, two in number, *Lucifuga* and *Stygicola,* have their nearest relatives in the surrounding ocean. They belong to the marine family *Brotulidae,* and their relatives are all found in the ocean. *Stygicola dentatus,* the larger of the Cuban blindfishes, is found both east and west of Havana, on both the north and south slope of the island. *Lucifuga subterraneus* is found only on the south slope west of Havana.

In southeastern Brazil, in the province of Santa Catharina, there are caverns containing blind catfishes, *Typhlobagrus Kronei;* the eyes of these are remarkably variable. Some specimens have no eyes at all, others have fairly developed eyes. They seem to be blindfishes in the making. Some of them have not yet arrived. Their relatives, *Pimelodella transitoria,* living outside these caves, are so similar to them that there can be no question about the origin of these blindfishes.

On the island of Marajó, opposite Pará, there is another blindfish. It is so different from the other South American fishes that we cannot say just what the ancestral species and genus were, although it was certainly near *Pygidium,* another of whose relatives is going blind in the plains of Bogotá.

In the streams of the high plateau surrounding Bogotá, "El Capitán del Bogotá" is very abundant. It is a speckled, eel-shaped, but shorter and thicker fish of a genus and species peculiar to the region about Bogotá, *Eremophilus mutisii* (Humboldt). It is provided with a number of barbels and has the habit of burrowing in the banks and bottom of the streams. I have seen many of them with but slight local variations. Recently I secured three specimens. One is without color, and normally colored in spots, and the eyes are normal. The second one is without color except in the normally developed eyes, which are black. The third is without color, and the eyes are also without color and scarcely visible externally. It is a blind fish. The first one has the appearance of a cross between the normal Capitán and one of the bleached blindfishes.

The development of blindfishes has very probably been along normal orderly lines of evolution and by processes still in operation. The cataclysmic origin, of which the origin by mutation is a modified revival, has been suggested and may not have been altogether excluded in one form or another, but it could only have been effective in a fish otherwise a proper candidate for blindness.

The processes by which the Point Loma blindfish has reached its present estate have been retained in various stages by its relatives. They live in burrows, but habitually lie in the pools about the burrows, descending only to escape danger. One can see them in numbers in the minute pools left at low tide. At the slightest danger they dive into their burrows. The blindfish has gone a step further. It lives permanently in the burrows. This does not mean that it may not occasionally come into open pools, but it could not maintain itself there, it could not avoid its enemies. If any foodstuff comes into contact with it anywhere, it turns flash-like to seize it.

The *Amblyopsis* of the Ohio Valley offers the double problem of its origin and its present distribution, being found both north and south of the Ohio. Its distribution can perhaps best be explained on the assumption that it did not originate at one point but developed all over its present range from its widely distributed ancestors with eyes. The salamander, *Spelerpes maculicauda,* is now becoming a permanent cave animal all over its range, wherever there are caves to be found. The cause and method of the origin of the present condition of the blindfish can best be seen at Horse Cave, Kentucky. At this place an east-and-west valley crosses a north-and-south valley. The north-and-south valley leads to the Green River Valley. The valleys at Horse Cave carry no water. The stream that is responsible for them runs 185 and more feet beneath the town of Horse Cave. The capping of the hills surrounding the valley is sandstone, the lower part limestone. The stream at one time ran above ground, first over sandstone, later over limestone, and drained into Green River. As the largest stream, Green River, lowered its bed more rapidly than the smaller ones, joints in the limestone became exposed, through which at first a small part, then, as the joints became enlarged by solution, more and more of the water of the valley found its way to Green River by subterranean channels. Later all the water ran below ground under normal conditions, and only during freshets did part of it run above ground. The various stages of the process can still be seen in the Lost River region of Indiana.

When the stream ran above ground, it probably had a varied fish fauna. Some of the fishes were pelagic in their habits, others haunted the shores and weeds, still others lived in crevices and under rocks. There may be assumed just such a fauna as is now found in Green River. As the Horse Cave Creek gradually disappeared beneath the ground, the pelagic and littoral fishes went out into Green River, those that were in the habit of finding their food and escaping their enemies in cracks and under stones stayed with the creek in its burrowing, and their modified descendants remain

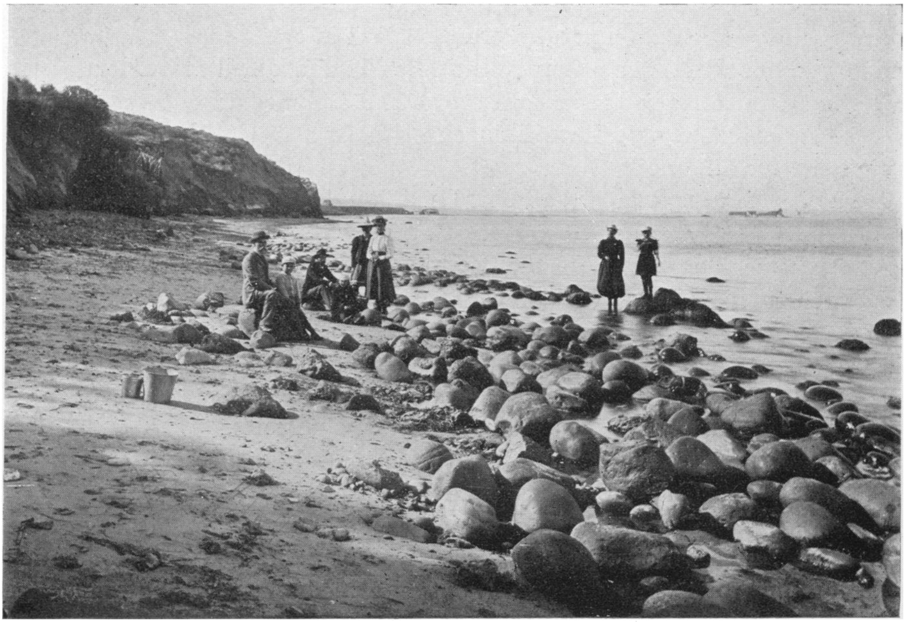


FIG. 10.

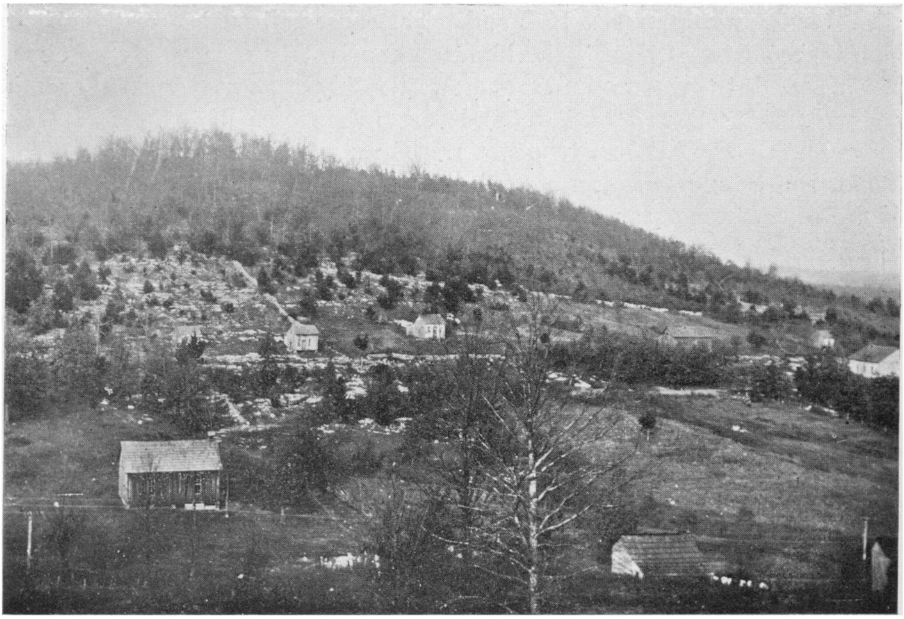


FIG. 11.

FIG. 10—Base of Point Loma, San Diego, California. Under the rocks in the burrows of a crustacean lives the Point Loma blindfish. It is a marine fish with various seeing relatives in the ocean and the Bay of San Diego. The blindfishes attach their eggs to the under side of the rocks. The young develop normal-sized eyes, which later lag behind in their development and degenerate with age.

FIG. 11—Looking across a valley near Horse Cave, Kentucky. The stream now flows nearly two hundred feet underground. Most of the animals which inhabited it when it flowed above ground migrated out to Green River when the stream was "lost." The ancestors of the blindfishes and the blind crawfishes went down with the river. Their modified descendants, the small blindfish and the blind crawfish, still live in this underground river.

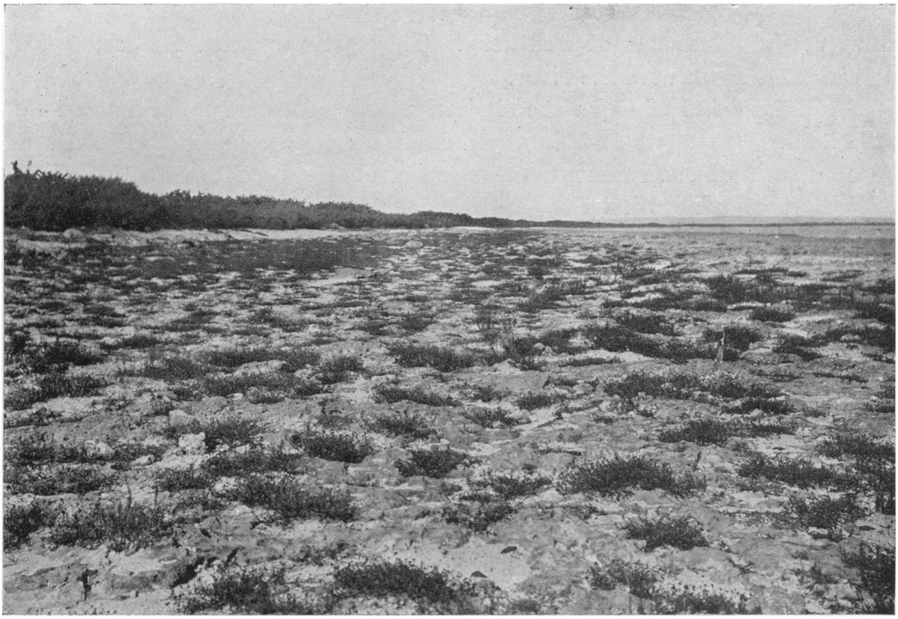


FIG. 12.

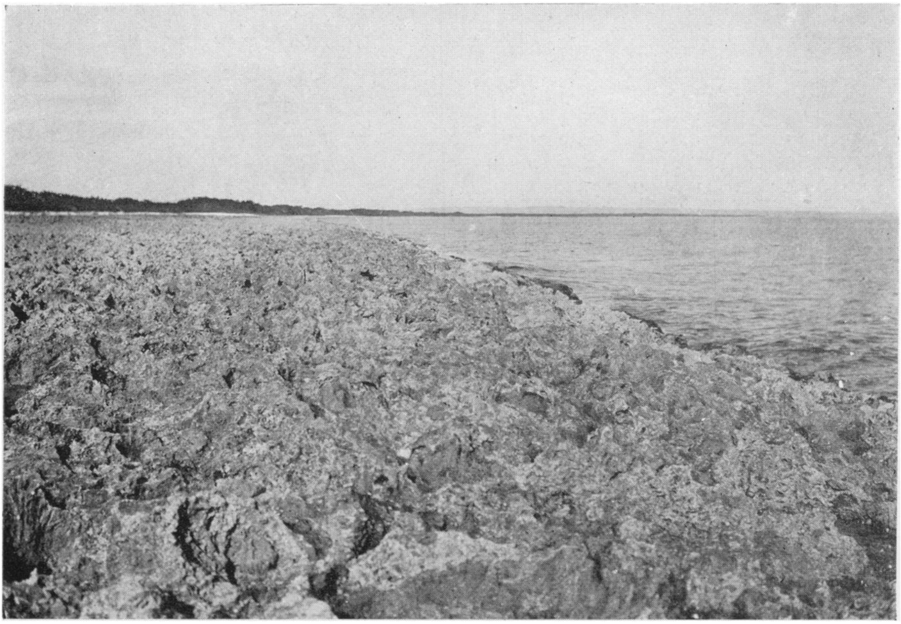


FIG. 13.

FIG. 12—Portion of the rocky beach near Matanzas, Cuba, farther back from the line of action of the waves. The pits in the surface of the rock have become filled with sand, which supports a scanty vegetation. A well in a rift only a few hundred yards inland from this point and only a few feet higher harbors many freshwater blindfishes.

FIG. 13—Rocky ocean beach within reach of the waves at Carbonera, near Matanzas. About these shores lives *Brotula*, a fish very closely related to the Cuban blindfishes. As similar rocky beaches became elevated and the sea water contained in the crevices was replaced by fresh water, the ancestors of the Cuban blindfishes became acclimated to fresh water.

today as the blindfishes of Kentucky. They grew up with the country, or rather, went down with the river.

The blindfishes of Cuba are similarly the result of the development of the island. Where we find, in any animal, a complex adaptation to a complicated unit of environment, there has probably been a concomitant development of adaptation and environment, as armor and armor-piercing projectiles are concomitant developments.

As stated, the relatives of the Cuban blindfishes do now, and the ancestors of the blindfishes probably did formerly, live in and about the coral reefs of Cuba. At Carbonera, near Matanzas, a crevice or rift can be seen in the coral beach a few feet above sea level. Its bottom is filled with sea water. A short distance inland is another similar rift in a beach at a slightly higher elevation. Its lower part is filled with fresh water and contains many blindfishes! The suggestion naturally offers itself that these fresh-water blindfishes were salt-water fishes living in this rift of the coral beach and that they remained in the rift as it became elevated and its water became gradually fresh. That they have become modified in further adaptation to their fresh-water and cave environment, goes without saying. They have always lived where they live now, but as the armor became modified, the adaptation of the projectile to armor also became modified.

The method of rearing the young is very different in the three blindfishes whose breeding habits we know.

The Point Loma blindfish lays eggs in clusters attached to the lower surface of rocks. They swell up and become elongate club-shaped soon after deposition. The young develop large eyes.

The Ohio Valley *Amblyopsis* has a peculiar adaptation to care for the young. The opening of the oviduct is far forward, and the eggs are deposited in the gill cavity to the number of about seventy. They are carried in the gills until after the young hatch and the yolk is absorbed, when the fish are about a quarter of an inch long. The eye begins to develop in the natural way, but very soon first one and then another part of the eye gives up, stops developing, and sooner or later begins to degenerate, so that in the very old there is nothing left but pigment and a few fragments of cartilage.

The Cuban blindfishes give birth to living young about an inch long. At birth the eyes appear well developed and are movable. They also begin to degenerate with age and growth and nearly reach the vanishing point in old age.